Superconducting RF Accelerating Cavity Developments

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Abstract.

At present, many accelerators favour the use of superconducting (SC) cavities as accelerating RF structures. For some of them, like long pulse Spallation Source or Transmutation Facility SC structures might be the only option.

For the high energy parts of such accelerators the well-developed multi-cell elliptic cavities are the most optimal. For the low energy part the elliptic structures cannot be used because of their mechanic characteristics. There is a scope of different already proven low-β SC cavities.

The main working conditions of the SC cavities are as follow:

- Very high electromagnetic fields – maximum magnetic field on the inner cavity surface up to Bpk=100 mT, maximum electric field on the inner cavity surface up to Epk=50 MV/m. These high field result in the strong Lorenz forces which cause the cavity wall deformation;
- Low temperature – down to 2K, that again causes wall displacements after cool down;
- The pulse regime of operation that results in the addition requirements on cavity rigidity;
- High vacuum conditions (10^{-9}-10^{-10}) and extra pressure on cavity walls from the helium tank also deform the cavity shape;
- High tolerances and quality surface requirements.

All deformations caused by these above mentioned reasons result in the working RF frequency shift in the range of hundreds kHz. Taking into account high Q-factor of SC cavities such big frequency shift brings cavity out of operation. From the other hand, the use of any external tuning elements like plungers or trimmers are problematic as it results in the low down cavity acceleration efficiency. It means all these factors should be taken into account and complex electromagnetic simulations together with structural analysis should be provided during any real cavity design.

Here we investigate the whole scope of the possible RF accelerating structures, which can be used for different relative particle velocity β=v/c starting from β=0.09 and ending up with β=1.0. The considered structures are quarter-wave and half-wave coaxial cavities (160 and 320 MHz, β=0.09-0.2), spoke cavity and based on spoke cavity geometry multi-cell H-cavities (700 and 350 MHz, β=0.2-0.5) and 5-cell elliptic cavities (700 and 350 MHz, β=0.5-1.0), which have been developed for various projects. All cavities optimised to reach the maximal accelerating electric field. The results of electrodynamics and structural analysis are presented. Some conclusions on cavity mechanical stability are made. The simulations also have been done for various vacuum and coupling port positions. Different cavity tuning schemes are under investigation and compared results are presented.

The comparison of numerical simulations with some experimental results are shown.